WELL TESTING

Alberta

88-05115/

WELL TESTING

Minimum Guidelines
For Safety Enhanced
Field Operations

On February 25, 1987 at the request of concerned testing companies and the Occupational Health and Safety Division of Alberta Community and Occupational Health, a general meeting of all well testing companies and interested oil companies was called.

Out of this meeting a committee was formed to prepare minimum guidelines for "Safety Enhanced Field Operations" as they pertain to well testing.

The committee met on a weekly basis for three months, compiling approximately 300 man hours in committee and a like amount on an individual basis.

We are confident that the procedures outlined in this booklet will, when followed, improve the industry's safety performance and prevent accidents.

The committee wishes to thank the following companies and agencies for their input and guidance:

Alberta Occupational Health and Safety Division
Energy Resources Conservation Board
Canadian Petroleum Association
Standard Safety Ltd.
United Resources Safety Ltd.
numerous oil company representatives

The committee's effort and time is gratefully acknowledged.

Fred Dankwerth, Chairman
Central Alberta Production Testing Ltd.

Terry Brown
Norward Energy Services Ltd.

Vic Hal
Opsco Industries Ltd.

Steve Hampton
Cantest Production Services Ltd.

Daryl Homan
Northland Production Testing Ltd.

Robb Martin
Accel Testing Inc.

Rod McBride
Genco Pressure Control Ltd.

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I. INTRODUCTION

The work on all gas and oil wells, whether producing, newly completed or recompleted is inherently risky. However, accident risks are reduced as safety awareness increases and consistent safe operating procedures are adopted. Enhanced safety can only be achieved when testing personnel are properly rested and trained.

Despite the urgency of well testing, it must not be executed at the expense of safety. The purpose of these guidelines is to alert testing personnel and the oil and gas industry in **minimum** safety requirements and, as well, to clarify conditions and operations peculiar to well testing. The more stringent safety requirements as per Occupational Health and Safety, Energy Resources Conservation Board, Customer Safety Publication or other authoritative bodies take precedence over the guidelines in this publication.

The well licencee/well operator is responsible for providing a detailed testing program. This work program shall clearly define the testing contractor's responsibilities. Any operator or third party equipment (including but not limited to wellhead, ESD valves, permanent process equipment, production tanks, flare stacks, safety equipment and so on) must meet applicable specifications and is the responsibility of the operator or his designated representative.

II. DEFINITIONS
(FOR THE PURPOSE OF WELL TESTING)

Sweet Wells: are known to contain less than 10 ppm H_2S (hydrogen sulfide), have no harmful or toxic substances and no corrosive or errosive agents.

Caution Wells: are known to contain from 10 to 10,000 ppm H_2S, have harmful or toxic substances, acids, and sand production, or maximum operating pressure in excess of 17 MPa.

Sour Wells: are known to contain any or all of the above plus significant harmful or toxic substances and/or more than 10,000 ppm H_2S.

Critical Sour Wells: as defined by industry and/or government regulatory bodies.

III. TESTING PERSONNEL RESPONSIBILITIES AND QUALIFICATIONS

Testing Supervisor:	is responsible for all aspects of the service company's performance on the job; must be adequately qualified, suitably trained and possess sufficient experience to perform the work with no direct supervision.
Shift Foreman/ Operator:	is responsible for all aspects of the service company's performance on a shift; must be adequately qualified, suitably trained and possess sufficient experience to work under minimal supervision.
Assistant Operator:	is responsible to work as directed by the supervisor or shift foreman and must be able to work under direct supervision.

IV. GENERAL SAFETY

All testing personnel must abide by the following minimum standards:

- CSA approved hard hats must be worn on location
- approved safety footwear must be worn on location
- the wearing of synthetic clothing that may cause static electricity is discouraged
- approved goggles must be worn where the eyes may be injured
- ear protection must be worn where hearing may be damaged
- proper gloves must be worn as per conditions
- smoking is not permitted within 25 m of potentially explosive equipment
- facial hair must not impede the sealing of respiratory protective equipment
- all personnel should possess valid first aid and H_2S certificates
- an approved first aid kit must be on location
- the safety stand-by system must be utilized for tank gauging or when working with fired equipment, caution wells, sour wells or critical sour wells
- approved fire extinguishers must be placed in accessible areas; minimum 2 on location or as prescribed herein (ABC or Purple K)
- a safety meeting must be held prior to start-up
- well site illumination must be adequate to safely perform any job and must be 8.5 m from potentially explosive equipment (unless Class 1 Division 1)

- initial pressure testing and/or well start-up must be limited to daylight hours, with a well-rested testing crew
- a mobile phone must be on location at all times
- a list of area RCMP, government authorities and hospitals must be near the mobile phone
- a means of transportation off location must be present, with an unobstructed exit path
- intoxicating substances or intoxicated persons are not allowed on location
- firearms on location are discouraged
- good housekeeping practice must be enforced at all times
- nonessential personnel must not be on location
- an adequate supply of potable water must be on location at all times
- where H_2S is present all personnel must possess a H_2S certificate
- H_2S detection apparatus must be available at all locations
- positive pressure breathing apparatus (minimum 2) must be on location at all times
- all H_2S determinations must be done wearing breathing apparatus
- flashlights must be explosion proof
- all personnel must comply with Dangerous Goods Regulations
- wind direction indicators must be present at all locations

V. EQUIPMENT SPECIFICATIONS

RECOMMENDED STANDARDS FOR PRESSURE CONTAINING COMPONENTS

A. Pressure Vessels

Pressure vessels must be designed and fabricated to ASME Section VIII Division 1, and be currently registered with the local Boilers Branch or applicable jurisdiction.

B. Pressure Piping

ANSI B31.3, "Petroleum Refinery Piping" should be used as the design pressure standard. Any of the 3 formulas in Part 2, Section 304 may be used, provided that allowable wall thickness reduction and thread depth are subtracted from nominal wall thickness. A corrosion allowance is not appropriate for well testing, as sudden erosion from abrasives is more of a hazard than corrosion. Companies are encouraged to perform routine ultrasonic thickness measurements of piping components, especially after suspected abrasive production. SE values for metals listed in Appendix A of ANSI B31.3 are those shown. High strength metals not listed in Appendix A may be used, provided that SE does not exceed 1/3 of minimum tensile strength in the material's final heat treated condition.

See Appendix A for pressure ratings of commonly used pipe.

C. Flanges

i) ANSI Flanges will have the pressure rating at design temperature as listed in ANSI B16.5. Unless higher temperatures are expected, the design temperature is 38°C (100°F).

ii) API Flanges will have the pressure rating of API 6A, and will be stamped on the flanges by the manufacturer.

D. Other Connections (Hammer Unions, Unibolt, etc.)

The pressure rating shall not exceed the manufacturer's specified Cold Working Pressure, which is **not** the test pressure. Caution should be exercised in defining the Cold Working Pressure of connections that have been tempered to meet H_2S service, as the Cold Working Pressure may be less than that of an untreated equivalent connection.

E. Flexible Piping (Chiosans, Coflex Hose, etc.)

Where the use of such piping components is necessary, the pressure rating shall not exceed the manufacturer's Working Pressure.

Special attention to possible defects must be part of the pre-test operation. Such piping must be tied back wherever possible, and special procedures must limit personnel access to the area of operation while under pressure.

F. Materials For H_2S Service

NACE Standard MR-01-75 (Current Revision) shall be the standard. The "Sour Oil & Multiphases" definition of an H_2S environment may be used where applicable, but use of the "Sour Gas" definition is encouraged. Under the "Sour Gas" definition, an H_2S environment exists when:

- H_2S Partial Pressure exceeds, .05 PSIA (.34 kPa), **and**
- System pressure is 65 PSIA (448 kPa) or greater.

$$\text{Partial Pressure equals} \quad \frac{\text{Mole \% } H_2S \text{ X Max. Operating Pressure}}{100}$$

Only materials in Tables 1 through 4 may be used. Special attention must be paid to Welding per Section 5.3 of NACE MR-01-75, which encourages post-weld stress relieving, and makes it mandatory unless a Welding Procedure Qualification has proven to result in HRC 22 maximum in the weld Heat Affected Zone and the base metal.

The user must ensure that there are no weak links of Sulfide Stress Cracking susceptible materials in a sour pressure containing system.

G. Welding & Pipe Threading

Line Pipe Threading is discouraged above 2500 PSIA (17 MPA) for nominal pipe sizes above 1″ (25mm), especially for Sour Gas service. As a minimum, the Line Pipe Threading ratings of API 6A will apply.

Nominal Pipe Size	**Maximum Cold Working Pressure**
To ½″ (13mm)	10,000 PSI (70 MPa)
¾″ - 2″ (19-50mm)	5,000 PSI (35 MPa)
2½″ - 6″ (64-152mm)	3,000 PSI (21 MPa)
EUE Tubing Threads	5,000 PSI (35 MPa)

Thread depth must be taken into consideration per Part B, and actual pressure rating is the lesser of this Part or Part B.

Other threads are allowable with full attention to Part B combined with engineering of the thread and strength of materials.

Welding should be to the complete requirements of ASME Section IX.

Post-weld stress relieving is discretionary, with special attention to the requirements of Part F for Sour Gas.

Weld radiography is recommended. Interpretation must be to an applicable standard. ANSI B31.3 is recommended.

H. System Pressure Rating

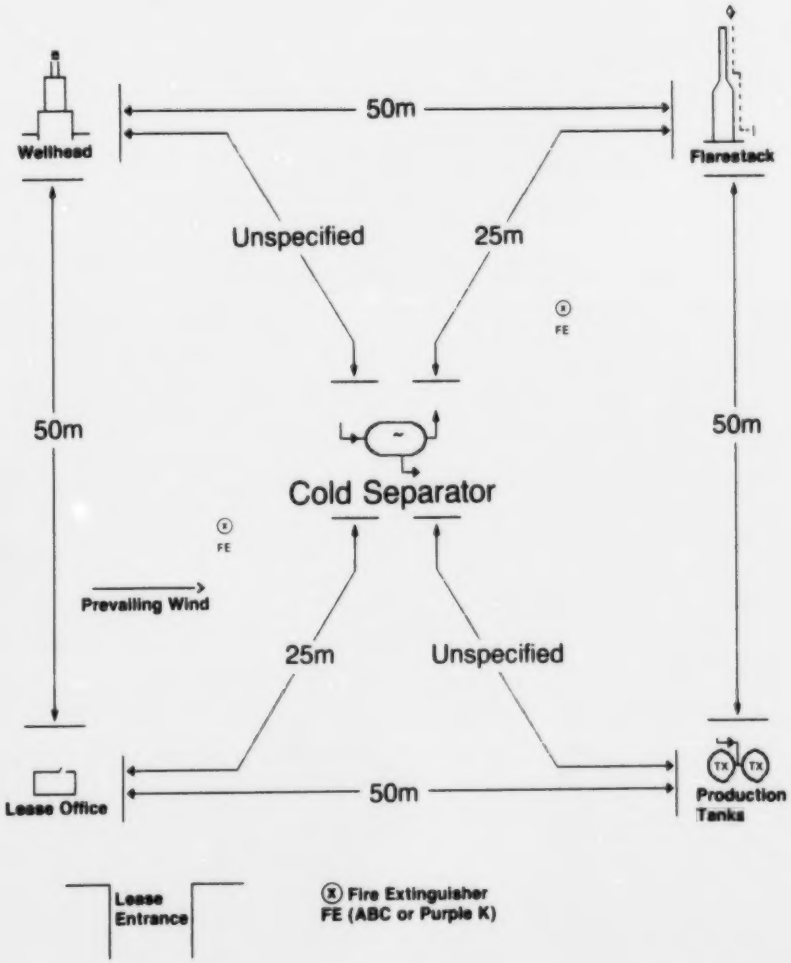
The system pressure rating is the pressure rating of the weakest link.

VI. EQUIPMENT REQUIREMENTS

LAYOUT GUIDELINES

START UP AND OPERATING PROCEDURES

A. SWEET WELLS
COLD SEPARATOR
MINIMUM SPACING REQUIREMENTS



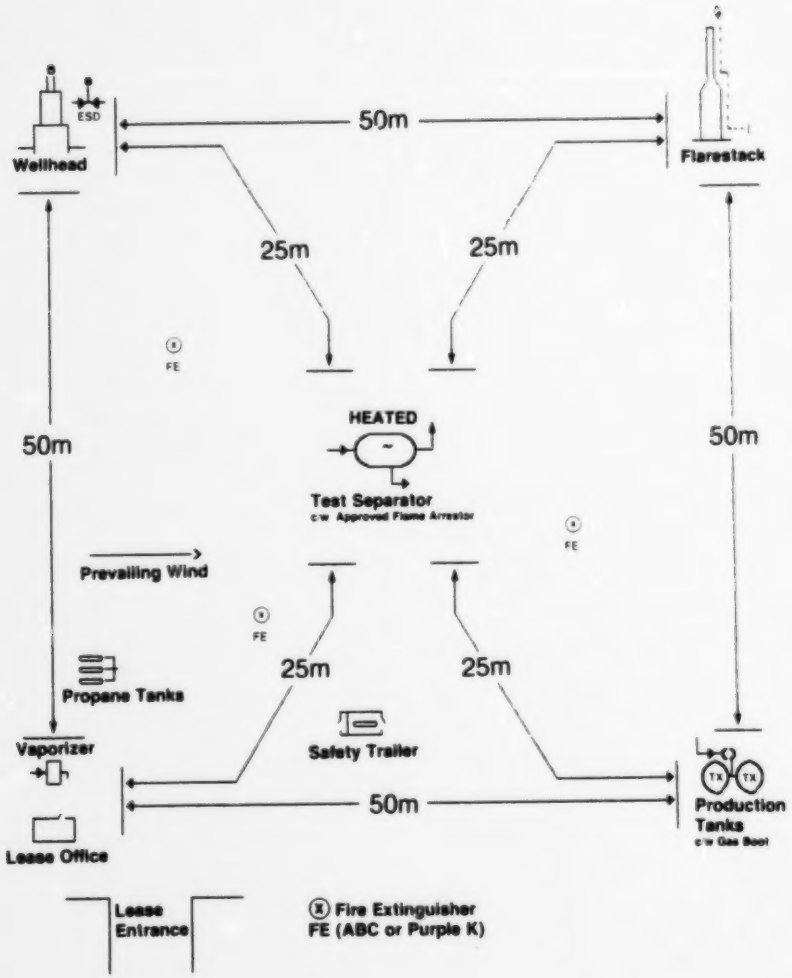
Start-Up And Operating Procedures - Sweet Wells - Cold Units

- ensure competent 4 man crew (2 test personnel required per shift)
- ensure equipment is adequate for the job
- spot equipment utilizing layout diagram guidelines
- rig in equipment
- stake or secure all lines
- electrically bond equipment to wellhead as required
- place fire extinguishers at accessible locations (minimum 2 × 20#)
- place flood lights at work areas (minimum 2)
- conduct a safety meeting and review work program
- remove nonessential personnel
- purge system (including tubing) of all air with well gas or with other suitable gas where applicable through a wing valve or choke (no fires)
- check for H_2S and periodically thereafter
- pressure test flow line and separator
- bleed down and repair leaks, if any
- repurge system
- prior to testing, a clean-up flow period is recommended
- start flow test as per program
- check entire system for leaks
- at shift change, review flowing conditions, conduct an equipment performance check and safety review
- upon shut-in, secure wellhead (chain and install tapped bull plugs with bleed off valves)

Sweet Wells:

- Under special circumstances, oil production tanks may be placed as close as 15.24m (50 ft.) to wellhead with ERCB permission. If water production only, no specific distance from wellhead required.
- In British Columbia flare stack must be 50m from separator.
- The distance from the base of the flare stack to the closest debris must be two and one-half times the height of the flare stack or such other distance as may be prescribed by the government authorities. Ref: The Forest and Prairie Protection Act Regulations (Part 1)

B. SWEET AND CAUTION WELLS
HEATED TEST UNIT
MINIMUM SPACING REQUIREMENTS



Start-Up And Operating Procedures - Sweet and Caution Wells - Hot Units

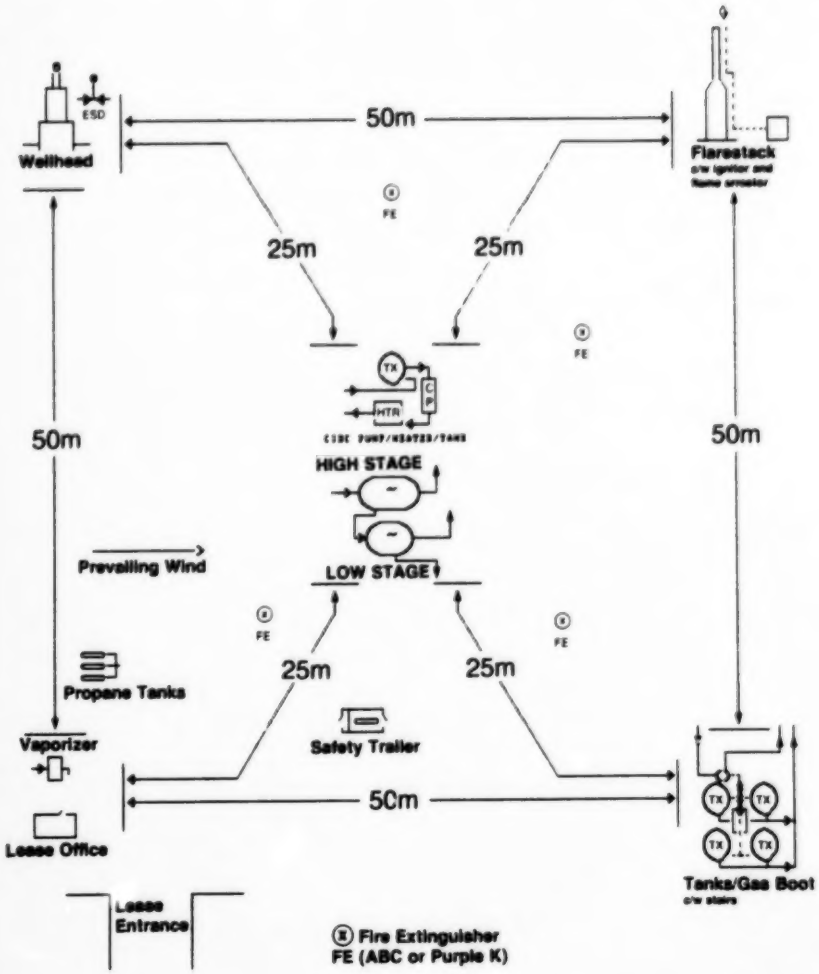
- ensure competent 4 man crew (2 test personnel or more required per shift dependent upon situation)
- ensure equipment is adequate for the job
- spot equipment utilizing layout diagram guidelines
- rig in equipment
- stake or secure all lines
- electrically bond equipment to wellhead as required
- place flood lights at work areas (minimum 3)
- place fire extinguishers at accessible locations (minimum 3 × 20#)
- position other safety equipment such as positive pressure breathing apparatus
- conduct a safety meeting and review work program
- remove nonessential personnel
- purge entire system (including tubing), of all air with well gas or other suitable gas where applicable with wing valve or choke (tubing must be clear of all air - no fires)
- check for H_2S and periodically thereafter
- pressure test
- bleed down and repair leaks if any (ensure no flashback from flare upon shut-in)
- repurge entire system
- if flare pilot is utilized, it may be lit
- a clean-up flow period is recommended prior to testing

- start flow test as per program
- check entire system for leaks
- at shift change, review flowing conditions, conduct an equipment performance check and safety review
- upon shut-in, secure wellhead (chain and install tapped bull plugs with bleed off valves)

Caution Wells May Require:

- ESD (emergency shut down) valve on wellhead c/w 3 shutdown stations. (One each at test unit, office trailer and near production tanks.)
- Sand frac manifold, sand separator, sand trap or filter, or sand boot.
- Propane tanks and vaporizer are required for supply fuel (heater and instrumentation) if well contains H_2S. Vaporizer must be a minimum of 3 metres from propane tanks.
- Safety trailer containing breathing apparatus (positive pressure) for all personnel working on location.
- The distance from the base of the flare stack to the closest debris must be two and one-half times the height of the flare stack or such other distance as may be prescribed by the government authorities. Ref: The Forest and Prairie Protection Act Regulations (Part 1)

C. SOUR WELLS
HEATED TEST UNIT
MINIMUM SPACING REQUIREMENTS



Sour Wells Require:

- ESD valve on wellhead c/w 3 shutdown stations. (One each at test unit, office trailer and production tanks)
- If a circulating system is required, a high pressure check valve (same working pressure as wellhead) must be installed on inlet and an ESD valve or storm choke must be installed on outlet.
- Production tanks and gas boot must be vented to flare stack. ULC approved inline flame arrestors must be installed on production tank vent line at base of stack. A shut off valve should be placed upstream of flame arrestor for pressure/vacuum control on production tanks and for maintenance check on flame arrestor. A shut off valve on gas boot should also be installed for pressure/vacuum control.
- For additional safety, it is recommended that a pressure (maximum 8 oz.) / vacuum (maximum 2 oz.) alarm or sensing system be installed on production tank vent line.
- A constant gas blanket (propane, sweet gas, N_2, or CO_2) should be maintained on production tanks at all times. When shipping from a production tank, ensure vent valve to flare stack is closed and an adequate gas supply to production tank is maintained.
- When shipping production fluid a shipping line of at least 10m in length should be installed. When loading, the tank truck should be vented to the production tank vent system or to a separate sweentening system. Ensure no air enters vent system. The tank truck must be bonded to ensure electrical continuity.

- Safety trailer containing breathing apparatus (positive pressure) for all personnel working on location.
- Safety stairway for production tanks.
- The distance from the base of the flare stack to the closest debris must be two and one-half times the height of the flare stack or such other distance as may be prescribed by the government authorities. Ref: The Forest and Prairie Protection Act Regulations (Part 1)
- Lease requires an alternate exit if the layout of the lease is such that production tanks may be near exit road.

Start-Up And Operating Procedures - Sour Wells

- ensure competent 6 man crew (3 test personnel per shift required)
- ensure all personnel have current H_2S alert certificates
- ensure all equipment is adequate for the job
- spot equipment utilizing layout diagram guidelines
- rig in equipment
- stake and secure all lines
- electrically bond equipment to wellhead as required
- place fire extinguishers at accessible locations (minimum 4 × 20#)
- place flood lights at work areas (minimum 4)
- position other safety equipment
- check ESD valve
- conduct a safety meeting, including equipment demonstration and review work program

- remove nonessential personnel
- purge entire system (including tanks), of all air preferably with a noncombustible gas such as N_2 or CO_2; extreme caution must be exercised when purging with combustible gases such as propane (minimum 1.5 times system volume displacement recommended) *
- all personnel must wear breathing apparatus
- pressure test
- bleed down and repair leaks, if any (ensure no flashback from flare upon shut-in)
- repurge system
- light flare pilot
- a clean-up flow period is recommended prior to testing
- start flow test as per program
- check entire system for leaks
- at shift change, review flowing conditions, conduct an equipment performance check and safety review
- upon shut-in, repurge system, corrosion inhibit test equipment and secure wellhead (chain and install tapped bull plugs with bleed off valves)

NOTE: With regard to the inline testing of sour wells where the system is enclosed, consideration may be given to a competent 4 man crew (2 test personnel per shift).

* When air is suspected in the tubing, as may occur in an underbalanced completion, it must be bled off. Run a direct line off wing valve or choke to flare, light pilot, flow until well returns are apparent, allow gas to dissipate, shut down pilot and then proceed to purge the entire system of all air.

D. CRITICAL SOUR WELLS:

- Minimum equipment spacing same as for sour wells.

Additional considerations:

- A high pressure relief system (minimum 3" high pressure steel line) should be connected to flare stack. Line must be adequately secured with swamp weights and/or stakes.
- A relief system should also be installed on the low stage separator.
- Continuous on-site H_2S monitoring should be on location at all times. Minimum of 3 sensing stations, one sensor at production tanks, one near wellhead and one near test unit.

Start-Up And Operating Procedures - Critical Sour Wells

- follow detailed program as per oil company and regulatory bodies

APPENDIX A
PRESSURE RATINGS FOR SEAMLESS PIPE

The standard is ANSI/ASME B31.3, "CHEMICAL PLANT & PETROLEUM REFINERY PIPING".

From Section 304.12 (3a)

$$P = \frac{2t\ SE}{D-2ty}$$

t = (t nominal X .875) -H, where .875 allows for a permissible 12.5% wall thickness reduction from tn, and H = thread depth.

* For NPT threads, H = .07531" up to 2", and .10825" above 2" pipe.

SE = 1/3 of minimum tensile strength, from ANSI/ASME B31.3 or actual tests.

For carbon steel (A53B, A106B, A333 Gr. 6, A334 Gr. 6), SE = 1/3 of 60,000 = 20,000 PSI

For AISI 4130, HRC 22 max, SE = 1/3 of 85,000 = 28,333 PSI. (For AISI 4130, 85,000 is quite conservative. Usual test results exceed 95,000 PSI minimum tensile strength)

D = nominal O.D.

y = .4 if t is less than or equal to D/6

$y = \frac{d}{d+D}$ if t is greater than D/6

where d = D - 2 (.875 tn)

The attached tables do NOT include a corrosion allowance. In well testing, sudden and violent erosion is certain to destroy well test pipe before corrosion.

If a corrosion allowance is subtracted,

NEW PRESSURE RATING APPROX. =

$$\frac{.875tn - \text{Corrosion allowance}}{.875\ tn} \times \text{OLD PRESSURE RATING}$$

* Ensure these thread depths are not exceeded, to meet the pressure ratings on the following pages.

PIPE SIZE in.	ACTUAL O.D., in.	PIPE SCHEDULE	NOMINAL WALL, in.	NOMINAL I.D., in.	PRESSURE RATING PSIG (ANSI B31.3)		
					WELDED CARBON STEEL	API 5H/5CRCO CARBON STEEL	WELDED 4130, RBC 22 Max.
1/2	.840	40(STD)	.109	.622		1000	
		80(XH)	.147	.546		2700	
		160	.187	.466		4550	
		XXH	.294	.252		9850	
3/4	1.050	40(STD)	.113	.824		900	
		80(XH)	.154	.742		2350	
		160	.219	.612		4850	
		XXH	.308	.434		8400(5000*)	
1	1.315	40(STD)	.133	1.049		1300	
		80(XH)	.179	.957		2600	
		160	.250	.815		4800	
		XXH	.358	.599		8250(5000*)	
1 1/2	1.900	40(STD)	.145	1.610		1100	
		80(XH)	.200	1.500		2200	
		160	.281	1.338		3850	
		XXH	.400	1.100		6500(5000*)	
2	2.375	40(STD)	.154	2.067	2400	1080	3400
		80(XH)	.218	1.939	3450	2500	4900
		160	.344	1.689	5650	4100	8000
		XXH	.436	1.530	7400	5750(5000*)	10450
2 1/2	2.875	40(STD)	.203	2.469	2600	1000	3700
		80(XH)	.276	2.323	3600	1950	5100
		160	.375	2.125	5000	3250(3000*)	7100
		XXH	.552	1.771	7750	5800(3000*)	11000
		XXXH	.750	1.375	10900	8800(3000*)	15400
3	3.500	40(STD)	.216	3.068	2250	950	3200
		—	.254	2.992	2800	1350	3800
		80(XH)	.300	2.900	3200	1850	4500
		—	.375	2.750	4050	2650	5750
		160	.438	2.624	4800	3350(3000*)	6800
		XXH	.600	2.300	6850	5300(3000*)	9700
		—	.750	2.000	8750	7100(3000*)	12400
		—	1.000	1.500	12000	10250(3000*)	17000

*VALUES IN BRACKETS ARE LIMITED BY API 6A

PIPE SIZE in.	ACTUAL O.D., in.	PIPE SCHEDULE	NOMINAL WALL, in.	NOMINAL I.D., in.	PRESSURE RATING PSIG (ANSI B31.3)		
					WELDED CARBON STEEL	NPT THREADED CARBON STEEL	WELDED 4130, RBC 22 Max.
3 1/2	4.000	40(STD)	.226	3.548	2050	900	2900
		80(XH)	.318	3.364	2950	1750	4200
		—	.500	3.000	4800	3500(3000*)	6800
		XXH	.636	2.728	6250	4900(3000*)	8850
		—	.750	2.500	7550	6150(3000*)	10700
		—	1.000	2.000	10400	8900(3000*)	14700
		—	1.250	1.500	13200	11650(3000*)	18700
4	4.500	40(STD)	.237	4.026	1900	900	2700
		—	.250	4.000	2000	1000	2850
		—	.312	3.875	2550	1500	3600
		80XH	.337	3.826	2750	1700	3900
		—	.364	3.772	3000	1950	4250
		120	.438	3.624	3650	2550	5200
		—	.500	3.500	4200	3100(3000*)	6000
		160	.531	3.438	4500	3400(3000*)	6400
		XXH	.674	3.152	5850	4700(3000*)	8300
		—	.750	3.000	6600	5400(3000*)	9350
		—	1.000	2.500	9100	7850(3000*)	12900
		—	1.250	2.000	11650	10300(3000*)	16500
		—	1.500	1.500	14100	12700(3000*)	19950
4 1/2	5.000	40(STD)	.247	4.506	1800	900	2550
		—	.250	4.500	1800	900	2550
		80(XH)	.355	4.290	2600	1650	3700
		—	.375	4.250	2750	1800	3900
		—	.500	4.000	3750	2800	5350
		XXH	.710	3.580	5500	4450(3000*)	7800
		—	.750				
		—	1.000	3.000	8100	6700(3000*)	11500
		—	1.250	2.500	10400	9200(3000*)	14700
		—	1.500	2.000	12650	11400(3000*)	17900
5	5.563	40(STD)	.258	5.047	1700	850	2400
		80(XH)	.375	4.813	2500	1650	3500
		120	.500	4.563	3350	2500	4750
		160	.625	4.313	4250	3350(3000*)	6050
		XXH	.750	4.063	5200	4300(3000*)	7400
		—	1.000	3.563	7300	6200(3000*)	11900

*VALUES IN BRACKETS ARE LIMITED BY API 6A

PIPE SIZE in.	ACTUAL O.D., in.	PIPE SCHEDULE	NOMINAL WALL, in.	NOMINAL I.D., in.	PRESSURE RATING PSIG (ANSI B31.3)		
					WELDED CARBON STEEL	NPT THREADED CARBON STEEL	WELDED 4130, RBC 22 Max.
6	6.625	—	.250	6.125	1350	700	1900
		40(STD)	.280	6.065	1500	850	2150
		—	.312	6.001	1700	1000	2400
		—	.375	5.875	2050	1350	2900
		80(XH)	.432	5.761	2400	1700	3400
		—	.500	5.625	2800	2050	3950
		120	.562	5.501	3150	2450	4450
		160	.718	5.189	4100	3350(3000*)	5800
		XXH	.864	4.897	5000	4250(3000*)	7100
		—	1.000	4.625	5900	5100(3000*)	8350
		—	1.125	4.375	6800	5950(3000*)	9600
		—	1.250	4.125	7600	6750(3000*)	10800

*VALUES IN BRACKETS ARE LIMITED BY API 6A